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PATENT SPECIFICATION

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DRAWINGS ATTACHED

1 259 249

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(54) IMPROVEMENTS IN OR RELATING TO THE CUTTING OF PLATE-SHAPED CRYSTALS INTO SMALLER PIECES

(71) We, SIEMENS AKTIENGESELLSCHAFT, a German Company, of Berlin and Munich, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a method of cutting a plate-shaped crystal into smaller pieces, and to apparatus for use in carrying out the method.

In industrial and indeed also in non-industrial electrical equipments, such as for example kitchen equipment, it is to an increasing degree becoming necessary to use semiconductor components whose power outputs are relatively low and whose external dimensions can therefore be relatively small.

The introduction of these small semiconductor components into electrical equipment on the one hand, and the large numbers in which they are required, on the other, necessitate the use of particularly economical methods of mass production. These manufacturing methods, however, must be so contrived that they also affect the electrical properties of the semiconductor components produced to as small an extent as possible.

Such affecting of the electrical properties of a semiconductor component can in particular occur at the time of separation of the component from a basic wafer of large area having a sequence of zones parallel to the face of the wafer, which zones are of alternating conductivity type. In separating the individual semiconductor components by sawing or splitting operations, deep damage formations in the crystal structure are produced at the cut surfaces, these damage formations virtually short-circuiting the p-n junctions which appear at the cut surface, so that these junctions do not have any blocking effect. It is true that the damaged crystal layers at the surface of the separated semiconductor components can be removed by etching; however, for this purpose, acid etching agents, such as, for example, a mixture of hydrofluoric acid and nitric acid, and long etching times are necessary, so that contact electrodes made of metal and also located on the semiconductor component are equally attacked by the etching agent.

According to the invention, there is provided a method of cutting a plate-shaped crystal into smaller pieces which comprises the steps of placing said crystal with a main face upwards on a grid, the face of said grid supporting said crystal being provided with a slot, directing a sand jet from a nozzle against said face of said crystal whilst effecting a continuous relative movement between said nozzle and the slot in said grid in the longitudinal direction of said slot to cut said crystal along the line of said slot by sand-blasting, whilst sucking away sand from said slot.

The crystal damage at the cut surface of the body separated from the crystal, is very slight indeed and can be removed very rapidly using alkaline etching agents which do not attack any metal electrodes located on the bodies, so that the blocking capacity of p-n junctions appearing at the cut faces are fully effective. Furthermore, sharply defined cuts are produced in the crystal and the edges of the separated body exhibit no breaks.

Apparatus for carrying out the method of the invention advantageously comprises a grid having a supporting surface for a plate-shaped crystal, this supporting surface having a pattern produced by two sets of parallel slots intersecting at right angles, a nozzle for directing a sand jet downwardly towards the supporting surface, means for effecting relative movement between the nozzle and any of the slots in the grid in the longitudinal direction of said slot, and means for

sucking sand from the slots. Conveniently, the grid comprises a plurality of comb-shaped elements spaced apart by spacers arranged between adjacent pairs of comb-shaped elements, the arrangement of comb-shaped elements and spacers being clamped together in a frame. A particularly easily manufactured grid can also be constituted by a metal block which, at the surface provided for supporting the crystal plate, is provided with criss-cross parallel slots and underneath is provided with bores opening into the slots for withdrawing the sand.

The invention will now be explained in more detail with reference to the drawings, in which:—

Figure 1 is a side elevation of apparatus for cutting a plate-shaped crystal into smaller pieces according to the invention,

Figure 2 is a perspective view of the grid shown in Figure 1,

Figure 3 is a plan view of part of the grid of Figure 2 on an enlarged scale,

Figure 4 is a section through the grid of Figure 2, taken along the lines A—B and B—C,

Figure 5 is a perspective view of another form of grid for use in the apparatus of Figure 1, and

Figure 6 is a section through the grid of Figure 5 taken along the line D—D.

Referring to Figure 1, the apparatus includes a base 2 having an opening 3 therein underneath which a suction pipe 4 is flange-fitted, the pipe 4 being connected to a suction device (not shown). On the base 2, above the suction opening 3 is a grid 5. The grid 5 is secured to the base 2 by two mutually opposite brackets 7 which engage in openings 6 on two mutually opposite side surfaces of the grid 5 and are screwed to the base 2. The openings or recesses 6 enable the grid 5 to be secured to the base 2 in an adjustable manner.

On the supporting surface 8 of the grid 5, which surface has advantageously been given a lapped finish to within close flatness tolerances, four circular crystal plates 9, which have simply been shown in broken line in order not to confuse the drawing, are laid flat. These crystal plates 9 are advantageously stuck to the supporting surface 8 which is slightly roughened by the lapping operation, with a cellulose varnish. The crystal plates 9 can, for example, be silicon plates having metal coatings on their main faces and in which a sequence of several zones parallel to the main faces and of alternating conductivity types are contained. Using the device shown in Figure 1, a plurality of small silicon components are to be produced from the silicon plates 9.

Above the base 2 a sand-blasting blower 10 is mounted with a nozzle 11 directed vertically onto the supporting surface 8 of the grid 5, the nozzle 11 advantageously having a slot-shaped mouth. This sand-blasting blower is secured in an adjustable manner to a horizontal mounting bar 12 and is provided at its upper end with a supply hose 14. The bar 12 is in turn secured in an adjustable manner to a mounting 13. The mounting 13 can be displaced both in the direction of the arrow 18 in the plane of the drawing, and also in the direction perpendicular to the plane of the drawing, parallel to the supporting surface 8 of the grid 5.

As shown in Figures 2 and 3, the grid 5 consists of a frame 5*a*, in which a set of flush metal combs 15 are clamped. The tips of the teeth of these metal combs 15, together form the supporting surface 8 of the grid 5, i.e. the surface which supports the crystal plates 9.

The base 2 is arranged to pivot in a plane parallel to the supporting surface 8. At its periphery, the base 2 is provided with a pin 17 the movement of which is limited by two stop blocks 18 which are so arranged that the base 2 can be pivoted through a maximum angle of 90°.

Figure 4 shows a section through the grid 5 and the base 2 taken along the chain-dotted lines A—B and B—C of Figure 2.

As the section taken along the line A—B shows at both sides of the grid 5, between each adjacent pair of combs 15, a strip-like spacer 16 is located. In this way, slots 21 parallel to the combs are formed in the supporting surface 8 as shown in the section B—C. As the section A—B shows, slots 24 perpendicular to the combs 15 are formed by the spaces between individual teeth of these combs.

After the crystal plates 9 have been stuck to the supporting surface 8 of the grid 5, the sand-blasting blower 10 is arranged with the orifice of the nozzle 11 over a slot 21 and, by displacing the mounting 13, is moved at a uniform rate in the direction of the arrow 18 along the slot 21, commencing from the frame 5*a* of the grid 5. By means of the stream of sand particles issueing from the nozzle 11, a separating cut is produced through two of the plates 9 above the slot 21. The sand used in the sand-blasting operation is sucked off from the slot 21 through the opening 3 beneath the grid 5. In this way, a build-up of sand and consequent clogging is avoided.

After the production of the separating cut above the slot 21, the mounting 13 is displaced perpendicularly to the plane of the drawing in Figure 1 (i.e. in the direction of the arrow 25 in Figure 2) so that the opening of the nozzle 11 is located over another slot 21. Thereupon, commencing once again from the frame 5*a* of the grid 5, the mounting 13 and thus the blower 10 are

moved in the direction of the arrow 18 along this new slot 21 at a uniform rate, and thus a further separating cut through two of the crystal plates 9 is produced.

After the production of the separating cuts located above the mutually parallel slots 21, the mounting 2 is pivoted through 90°. Then, in the same way as before, separating cuts are made through the crystal plates 9 along the slots 24 which are perpendicular to the slots 21. Subsequently, the tiny silicon bodies thus cut out of the plates 9, are released from the supporting surface 8 of the grid 5, for example, using acetone.

If the crystal plates 9 are made of 0.3 mm thick silicon and if they are provided on both main faces with a nickel layer of between 3 and 5 μ in thickness, then a cutting rate of between 3 and 5 cm/min has been found to be expedient. The width of the cut is advantageously 0.2 mm. This width of cut is obtained with a nozzle 11 having a slot-shaped opening with a width of 0.15 mm. The width of the slots 21 and 24 in the grid 5 is advantageously somewhere between 2 and 3 times that of the slot-shaped opening in the nozzle 11. The sand used advantageously has a grain size of between 10 and 30 μ, preferably 20 μ.

After the cutting of the silicon plates 9 into the small silicon bodies, which are already provided with flat electrodes, these bodies are etched for 1 to 2 minutes in an aqueous solution of KOH or NaOH. The damage to the crystal structure produced by the sand-blasting operation and occurring at the surface of these silicon bodies is so slight that the damaged portion can be completely removed by this short etching operation and the p-n junctions appearing at the cut surfaces have full blocking capacity without there being any risk of the metal electrodes being damaged in any way whatsoever.

The blower 10 can also be provided with a plurality of parallel nozzles so that it is possible simultaneously to produce several parallel separating cuts through the crystal plates 9.

The alternative form of grid shown in Figure 5 consists of a metal block 31 in the form of a parallelopiped which, on the supporting surface for the semiconductor plates 9, is provided with criss-cross parallel slots 32 and 33. Otherwise, similar components have been given the same reference numerals as in Figure 2.

As the section along the line D—D illustrated in Figure 6 shows, the criss-cross parallel slots 32 and 33 extend down to about half the height of the metal block 31. The lower part of the block 31 is provided with suction bores 44 which are advantageously located accurately beneath the points of intersection of the slots 32 and 33 in the upper part of the block 31.

The grid 31 of Figures 5 and 6 can be secured to the base 2 above the suction opening 3 in exactly the same way as the grid 5 of Figure 2.

WHAT WE CLAIM IS:—

1. A method of cutting a plate-shaped crystal into smaller pieces which comprises the steps of placing said crystal with a main face upwards on a grid, the face of said grid supporting said crystal being provided with a slot, directing a sand jet from a nozzle against said face of said crystal whilst effecting continuous relative movement between said nozzle and the slot in said grid in the longitudinal direction of said slot to cut said crystal along the line of said slot by sand-blasting, whilst sucking away sand from said slot.

2. A method as claimed in Claim 1, wherein said support face of said grid is provided with a plurality of slots and wherein said cut by sand-blasting is along some or all of said slots successively or simultaneously to separate said plate into a plurality of smaller pieces.

3. Apparatus for carrying out a method as claimed in Claim 1, comprising a grid having a supporting surface for a plate-shaped crystal, said supporting surface having a pattern produced by two sets of parallel slots intersecting at right angles, a nozzle for directing a sand jet downwardly towards said supporting surface, means for effecting relative movement between said nozzle and any of the slots in said grid in the longitudinal direction of said slot, and means for sucking sand from said slots.

4. Apparatus as claimed in Claim 3, wherein said grid comprises a plurality of comb-shaped elements spaced apart by spacers arranged between adjacent pairs of comb-shaped elements, the arrangement of comb-shaped elements and spacers being clamped together in a frame.

5. Apparatus as claimed in Claim 3, wherein said grid comprises a metal block, said slots extending from said supporting surface partly through the thickness of said block, and a plurality of suction bores communicating with said slots being provided in the side of said block opposite to said supporting surface.

6. Apparatus as claimed in any one of Claims 3 to 5, wherein said grid is mounted on a base rotatable in a plate parallel to said supporting surface.

7. Apparatus as claimed in any one of Claims 3 to 6, wherein said grid is mounted on a base provided with a suction orifice communicating with said slots and connected to suction means.

8. A method of cutting a plate-shaped

crystal into smaller pieces substantially as hereinbefore described with reference to the drawings.

9. Apparatus for cutting a plate-shaped crystal into smaller pieces substantially as hereinbefore described with reference to and as shown in Figure 1 and Figures 2 to 4, or Figures 5 and 6, of the drawings.

10. A piece cut from a plate-shaped crystal by a method as claimed in Claim 1, or Claim 2, or Claim 8.

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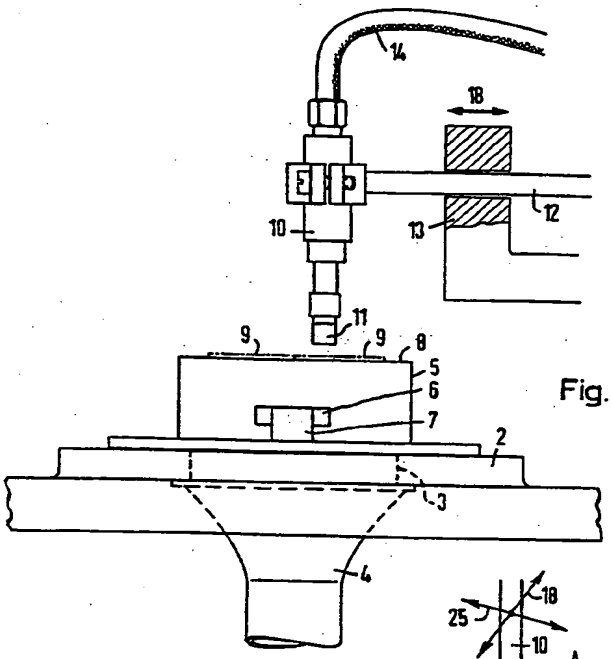

Fig.1

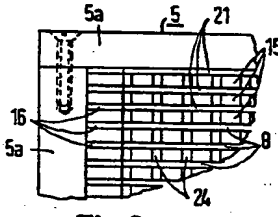

Fig.3

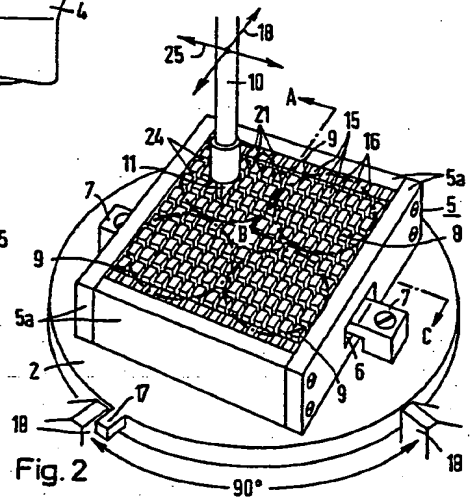

Fig.2

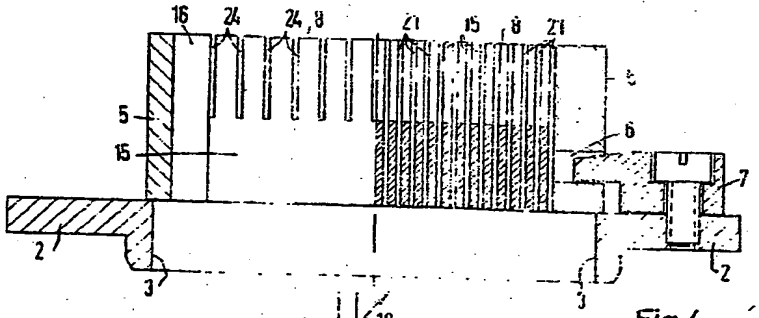

Fig.4

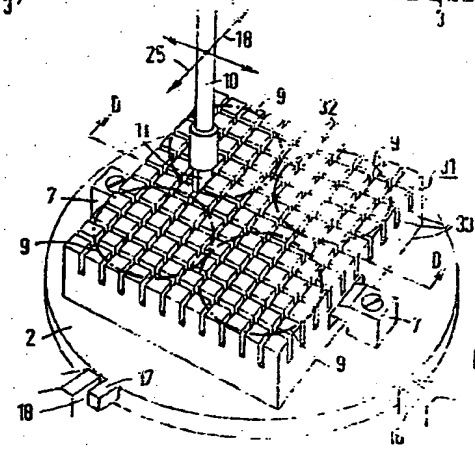

Fig.5

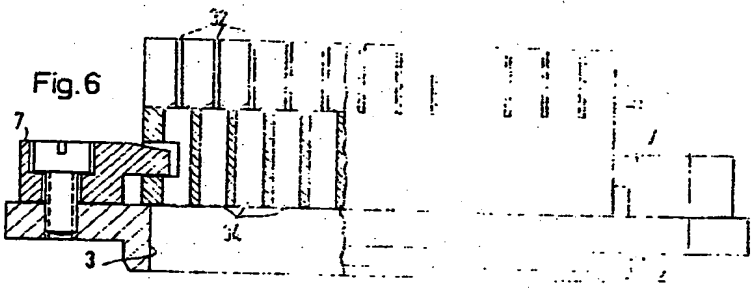

Fig.6